Monitoring and Action Thresholds for Onion Thrips in the 1999 / 2000 Season

Karyn Froud, Robert Petry, Lisa Jamieson
May 2000

Confidential Report to New Zealand Onion Exporters Association

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HortResearch Client Report No. 2000/333
HortResearch Contract No: 7503

This report has been prepared by The Horticulture and Food Research Institute of New Zealand Ltd (HortResearch) which has its Head Office at Batchelar Research Centre, Private Bag 11 030, Palmerston North and has been approved by:

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Date: 12/6/00	Date: 1/6/00

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EXECUTIVE SUMMARY

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Resistance by onion thrips (*Thrips tabaci*) to insecticides is a serious problem in the Pukekohe district. The control strategy being adopted for onion thrips is to develop systems to allow targeted applications of the pesticides at times which will have maximum impact on thrips, rather than relying on regular calendar based spray programmes.

For the 1998–1999 growing season, an Insecticide Resistance Management Strategy (IRMS) was developed to overcome the problems of thrips control failures. This involved using thresholds to determine when to commence spraying, cluster spraying of insecticides, a rotation of insecticides, and not using the synthetic pyrethroids (SP) products before early January.

An action threshold of 42% of onion plants infested was suggested. The efficacy of this monitoring system and the action threshold was assessed on six sites last season and was found to be inappropriate under the high thrips pressure in the Pukekohe district (Froud 1999).

The overall levels of control achieved with the 1998–1999 IRMS were inadequate to prevent thrips infestation of bulbs at harvest and in shipments overseas (Froud *et al.* 1999). This is believed to be due to a combination of:

- A threshold which was too high leading to a delay in starting to control thrips with insecticide sprays.
- A very hot summer which favoured rapid thrips multiplication.
- The short effective life of the few chemical products available.
- The large thrips population which had developed in some areas from the previous season.

The IRMS was revised and a very low action threshold rate of 5 thrips per 50 plants was recommended in comparison to 65 thrips per 50 plants (the equivalent of 42% of plants (R^2=0.91) infested with thrips) (Froud 1999).

The objectives of this season's research were:

A) Assess the sampling accuracy of the 1999-2000 IRMS monitoring system.

B) Assess the efficacy of the revised IRMS action threshold of 5 thrips per 50 plants.

OUTCOMES

In an assessment of the sampling accuracy of the monitoring system, samples of 50 plants were compared with larger sample sizes. There were no significant differences between sampling sizes of 50, 100, 150 and 200 plants assessed at four stages of the growing season. Considering the very conservative action threshold that was set for this season and the relatively good control of thrips in fields under this threshold, increasing the sample size was of limited value. The low action threshold value was arrived at with the consideration of of limited value. The low action threshold value was arrived at with the consideration of uneven population distributions and a small sampling unit. In general, thrips population densities this season were much lower than those recorded in the Pukekohe region during the 1998-1999 season. A large increase in thrips numbers was recorded at two sites in mid-October. Due to these early population increases we believe it would be advisable to begin sampling 1-2 weeks earlier (at the beginning of October) and that weekly sampling of 50 plants be implemented rather than two-weekly samples of 100 plants.

Excellent control of thrips populations in the Pukekohe region was observed at three early to mid season onion sites this season with thrips numbers being contained at or around the action threshold level. At the two late season sites much less control success was achieved than at the three earlier sites despite greater insecticide use. However all sites this season were able to achieve considerably better thrips control than in the previous season. A large proportion of this success would be attributable to the combination of the lower action threshold and earlier insecticide intervention. Due to these results we recommend retaining the current action threshold of 5 thrips per 50 plants.

Good early season control, as was demonstrated on the three early to mid season sites is probably the most important factor for reducing thrips numbers at harvest. Potentially only one or two spray clusters are necessary over the early season period just prior to top-fall.

It appears that early and mid-season harvested onions have lower thrips populations present at topping and require less insecticide intervention over the season than later crops. It may be that the level of insecticide application needed to protect a late crop is not sustainable.

Finally, some additional monitoring data were obtained from sites in the Canterbury and Manawatu regions (two and three sites respectively). Good levels of thrips control were observed for both Manawatu sites and Site 3 from Canterbury and this level of control corresponded with appropriate spray applications. Sites 1 and 2 from Canterbury had good control at the start of their respective growing periods, but thrips numbers greatly exceeded the threshold towards the end and middle of their respective growing periods and thrips population control was lost. This was most likely due to lack of spray applications at the time thrips numbers began to increase and too long an interval between spray applications.

RECOMMENDATIONS

- We recommend retaining the 50 plant sampling unit.
- Commencing sampling at the beginning of October.
- Taking weekly samples of 50 plants from October onwards.
- Retaining the 5 thrips per 50 plants action threshold.

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INTRODUCTION

There is increasing pressure from world markets to reduce pesticide use on food crops. The control of onion white rot, downy mildew and onion thrips accounts for a large proportion of pesticides applied to onion crops in New Zealand. In addition to food safety aspects, the potential for the target pests to develop resistance to the pesticides is of immediate concern to growers. Resistance by onion thrips (*Thrips tabaci*) to insecticides is already a serious problem in the Pukekohe district. The control strategy being adopted for all these pests is to develop systems to allow targeted applications of the pesticides at times which will have maximum impact on the pest, rather than relying on regular calendar based spray programmes.

For the 1998–1999 growing season, an Insecticide Resistance Management Strategy (IRMS) was developed to overcome the problems of thrips control failures. This involved using thresholds to determine when to commence spraying, cluster spraying of insecticides, a rotation of insecticides, and not using the synthetic pyrethroids (SP) products before early January. This was developed as the first year of a two-year programme.

A recommendation of the IRMS 1998-1999 (Wood and Martin 1998) for control of onion thrips was that pesticides should only be applied when thrips populations exceed action thresholds. This involved a method where presence or absence of thrips was recorded. An action threshold of 42% of onion plants infested was suggested. The efficacy of this monitoring system and the action threshold was assessed on six sites last season and was found to be inappropriate under the high thrips pressure in the Pukekohe district (Froud, 1999).

The overall levels of control achieved with the IRMS in the 1998–1999 season were inadequate to prevent thrips infestation of bulbs at harvest and in shipments overseas (Froud *et al.* 1999). This is believed to be due to a combination of:

- A threshold which was too high leading to a delay in starting to control thrips with insecticide sprays.
- A very hot summer which favoured rapid thrips multiplication.
- The short effective life of the few chemical products available.
- The large thrips population which had developed in some areas from the previous season.

Due to unreasonably high numbers of thrips occurring in onion bulbs at the end of last season, it was necessary to reduce the recommended action threshold to a very low level this season. The revised strategy recommends an action threshold rate of 5 thrips per 50 plants in comparison to 65 thrips per 50 plants (the equivalent of 42% of plants infested with thrips R^2=0.91)) (Froud 1999). This new threshold is very conservative and may be lower than necessary, which could result in more insecticides being applied than are warranted. As the aim of the strategy is to minimise insecticide use, the efficacy of this threshold is considered, alongside a slightly higher threshold of 10 thrips per 50 plants this season.

Last season's sampling research determined that a sample size of 50 plants per field was adequate to accurately assess the thrips population within the field. However, when a lower threshold is employed it is likely that the sample size will have to be increased to achieve an equivalent level of accuracy, particularly early in the season when thrips numbers are very low. This is particularly important in onion thrips populations which show a patchy distribution, as it is possible to under-estimate the population if too few samples are taken. Therefore, the objectives of this seasons research are as follows:

OBJECTIVES

A) Assess the sampling accuracy of the 1999-2000 IRMS monitoring system.

B) Assess the efficacy of the revised IRMS action threshold of 5 thrips per 50 plants.

METHODS

Detailed assessments of the new monitoring system and the revised action threshold commenced on the 12th October 1999 (4-5 weeks earlier than in the previous season), and continued until each crop was topped. Seven fields in the Pukekohe region were assessed on the properties of five growers:

Main assessment sites

Pukekohe region:	
Early sites	Site 1
	Site 2 high and low threshold fields
Mid sites	Site 3
Late site	Site 4 high and low threshold fields
	Site 5

Monitoring data was also collected by trained field monitors in 5 additional sites from the Canterbury and Manawatu regions.

Additional sites

Canterbury region:	Canterbury 'Site 1'
	Canterbury 'Site 2'
	Canterbury 'Site 3'
Manawatu region:	Manawatu 'Site 1'
	Manawatu 'Site 2'

Objective A: Sampling accuracy of the revised monitoring system

Assessment of the sampling accuracy of the monitoring system was conducted at three sites in Pukekohe (Sites 3, 4 and 5). Sample sizes of 50, 100, 150 and 200 plants were assessed for thrips numbers at each site following the general pattern laid down in the structured sampling plan (Figure 1). This assessment was repeated monthly at each of the sites during the growing season, timed to coincide with different thrips population densities.

Sample dates:	26th October 1999
	16th November 1999
	21st December 1999
	18th January 2000

The January assessment was only carried out at Sites 4 and 5 as Site 3 had been topped by this date.

Three statistical comparisons were made on each sampling occasion (one for each site, sites 3-5). Using the null hypothesis:

Ho = There is no significant difference in the mean number of thrips per plant for different sized samples (n= 50, 100, 150, 200) at either low (early / mid season), or medium / high (late season) thrips population densities.

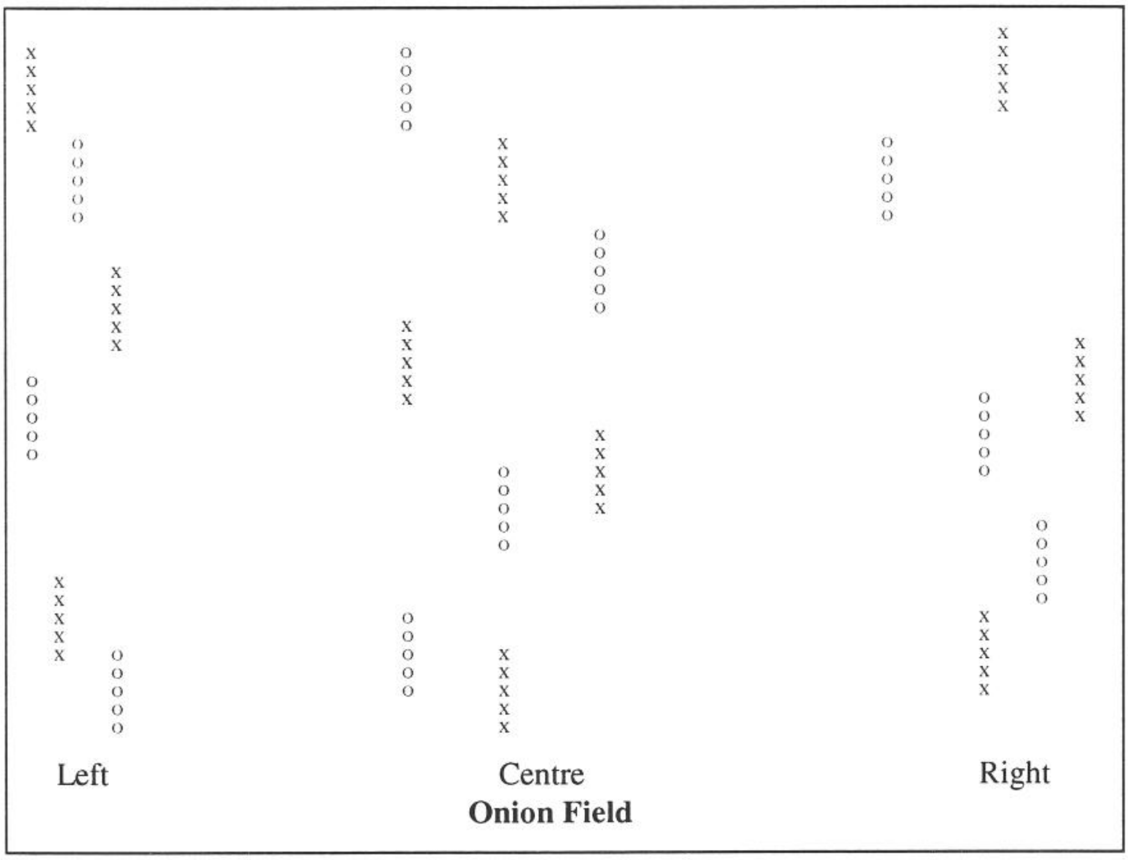
Statistical analyses for significant differences were performed using ANOVA and T-tests. Following a significant ANOVA ($P < 0.05$), treatments were compared using Fisher's least significant difference test. Data were analysed using the computer programme SAS (SAS Institute Inc. 1985).

In addition to the analysis of sample sizes the distribution patterns of the thrips populations within the fields at all five sites were assessed over the season. Assessment was made by calculating the coefficient of variation for each site at each sample date. The coefficient of variation (V) shows the type of distribution a population has by determining the variability within the samples. To calculate the coefficient of variation the equation below is used:

V (coefficient of variation) = SD/mean

Where SD = standard deviation
Mean = mean number of thrips per plant
$V=1$ Randomly distributed population
$V>1$ Patchy or clumped distribution
$V<1$ Evenly distributed population

Figure 1. Structured sampling plan



Where:	x	Approximate sample plan for 50 plant samples
	x and o	Approximate sample plan for 100 plant samples

Objective B: Efficacy of the revised action threshold

Detailed research on the efficacy of the revised action threshold was conducted at all seven fields in the Pukekohe district (as listed above), along with additional information provided from Canterbury and Manawatu.

Monitoring occurred at two weekly intervals in October and then weekly from November until harvest (Tables 1 and 2). The sample rate of 50-100 plants per field and the threshold of 5 thrips per 50 plants were followed as recommended in the revised strategy (see below).

At two of the Pukekohe sites (Sites 2 and 4) an extra field, adjacent to the first, was also sampled following the methodology in the revised strategy. However, spray decisions at these two extra fields were based on an action threshold of 10 thrips per 50 plants. Actual plants sampled differed between sample dates.

Efficacy was assessed by the ability of the spray timing and applications to keep the thrips populations to manageable levels over the season. This season's thrips numbers are compared to the thrips numbers last season where control of thrips was not achieved.

The impact of individual insecticides and spray clusters will not be covered in this report as this assessment will be presented by Martin *et al.* It was intended that a final post-harvest bulb assessment be carried out for these fields. However, funding priorities have instead allowed an in-depth post-harvest bulb assessment project to be carried out on several harvest techniques and this research will be presented by Tomkins *et al.*

Table 1. Sample dates for the Pukekohe region sites

Date	Site 1	Site 2 High	Site 3 Low	Site 3	Site 4 High	Site 4 Low	Site 5
12 Oct 99	√	√	√	√	√		√
19 Oct 99	√						
26 Oct 99	√	√	√	√	√	√	√
2 Nov 99	√	√	√	√	√	√	√
9 Nov 99	√	√	√	√	√	√	√
16 Nov 99	√	√	√	√	√	√	√
23 Nov 99	X[1]	√	√	√	√	√	√
30 Nov 99	√	√	√	√	√	√	√
7 Dec 99	√	√	√	√	√	√	√
14 Dec 99	√	√	√	√	√	√	√
21 Dec 99	√	√	√	√	√	√	√
28 Dec 99	√	√	√	√	√	√	√
5 Jan 00	√	√	√	√	√	√	√
12 Jan 00			√	√	√	√	√
19 Jan 00			√		√	√	√
25 Jan 00			√		√	√	√
3 Feb 00					√	√	√
8 Feb 00					√	√	√
15 Feb 00							√

[1] Sample not taken due to spraying.

Table 2. Sample dates for the additional sites

Date	Canterbury Site 1	Canterbury Site 2	Canterbury Site 3	Manawatu Site 1	Manawatu Site 2
10 Nov 99			√		
18 Nov 99			√		
19 Nov 99	√	√			
24 Nov 99			√		
26 Nov 99	√	√			
30 Nov 99			√		
3 Dec 99	√	√			
6 Dec 99			√		
10 Dec 99	√	√			√
14 Dec 99			√	√	
17 Dec 99	√	√			
22 Dec 99			√		
23 Dec 99					√
24 Dec 99	√	√			
29 Dec 99			√		
30 Dec 99				√	
31 Dec 99	√	√			
7 Jan 00	√	√			
12 Jan 00					√
14 Jan 00	√	√			
17 Jan 00			√	√	
26 Jan 00					√
27 Jan 00				√	
28 Jan 00	√	√			
4 Feb 00	√	√		√	√
14 Feb 00	√	√			
16 Feb 00					√
21 Feb 00	√	√		√	
29 Feb 00		√			√
3 Mar 00				√	

Revised IRMS Sampling Plan 1999–2000

Spraying with an insecticide should only commence if thrips are detected in excess of the numbers in the decision tables below (Tables 3 and 4). It is a much lower threshold than used in the 1998–1999 season.

***a) Early crop stages until end of October*.**

At 2 weekly intervals inspect **a total of 100** plants (20 subsets of 5 consecutive plants) per field following the pattern of the structured sampling plan (Figure 1).

Examine the neck area closely by separating the leaves, and also inspect any folded leaves in the upper canopy (more common late in the season). Note the ***number of thrips*** present, either as larvae or adults, and record this.

Cover the field with about half the sampling spots on all field edges, within about 25 metres of the edges, and the balance across the central part of the field (see Figure 1).

Table 3. Decision tables for spray action in October

100 plant sample	
Total thrips	**Action to be taken**
1	DON'T SPRAY
2	DON'T SPRAY
3	DON'T SPRAY
4	DON'T SPRAY
5	DON'T SPRAY
6	DON'T SPRAY
7	SAMPLE AGAIN NEXT WEEK
8	SAMPLE AGAIN NEXT WEEK
9	SAMPLE AGAIN NEXT WEEK
10	SPRAY
More than 10	SPRAY

b) Mid season onwards, November to before top-fall.
At weekly intervals inspect 50 plants in each field, as 10 sets of 5 plants.

Table 4. Decision tables for spray action from November onwards.

50 plant sample	
Total thrips	**Action to be taken**
1	DON'T SPRAY
2	DON'T SPRAY
3	SAMPLE 100 PLANTS (use next table)
4	SAMPLE 100 PLANTS (use next table)
5	SPRAY
More than 5	SPRAY

100 plant sample	
Total thrips	**Action to be taken**
1	DON'T SPRAY
2	DON'T SPRAY
3	DON'T SPRAY
4	DON'T SPRAY
5	DON'T SPRAY
6	DON'T SPRAY
7	SPRAY NEXT WEEK
8	SPRAY NEXT WEEK
9	SPRAY NEXT WEEK
10	SPRAY
More than 10	SPRAY

c) Before top-fall
Apply 3 – 4 sprays to ensure a high level of control of thrips. Sprays applied after top-fall have limited contact with the thrips in the neck area and folded leaves and result in poor levels of control at this stage. It is critical to have good control before top-fall commences.

Recommended Insecticide Application

Each insecticide product needs to be used as a cluster of 3 or 4 sprays to substantially reduce a whole generation of thrips each time. The time interval between sprays in a cluster is:

October	14 days
November	7 - 10 days
December – March	5 - 7 days

After completing a cluster of sprays do not use any insecticide again until monitoring shows the threshold of total number of thrips has been exceeded.

Choice of insecticide

Do not use SP products on onion crops before early January.

Use alternative chemicals to SP products before the pre-topfall sprays. Rotate the use of insecticide groups for each cluster of sprays before this period.

After early January the choice of insecticide from the SP, Organophosphates (OP), or other group can be continued at each grower's choice, but rotation of these groups still needs to be continued, and the withholding periods must be considered.

RESULTS AND DISCUSSION

Objective A: Sampling accuracy of the revised monitoring system

Statistical analysis for the October sample (low thrips density) showed no significant differences ($P<0.05$) in mean number of thrips per plant between sample sizes (n= 50, 100, 150, 200) at sites 3,4 and 5. Mean number of thrips per plant and the corresponding spray decision for each site at each sampling size are presented in Table 5. Spray decisions are based on a mean of 0.1 thrips per plant, which is equivalent to the threshold of 5 thrips per 50 plants. All spray decisions in the October samples were the same for all sites at all sampling densities.

Table 5. Mean number of thrips per plant and spray decisions for each site at four different sample sizes (n= 50, 100, 150, 200) in October (27 Oct 99).

Sample size	Site 3		Site 4		Site 5	
	Mean	Decision	Mean	Decision	Mean	Decision
50 plants	0.00	Don't spray	0.60	Spray	0.04	Don't spray
100 plants	0.00	Don't spray	0.42	Spray	0.02	Don't spray
150 plants	0.01	Don't spray	0.45	Spray	0.01	Don't spray
200 plants	0.01	Don't spray	0.49	Spray	0.02	Don't spray

The November sample (also at relatively low thrips density) statistical comparisons also showed no significant differences between sample sizes. However, when spray decisions are assigned to the means of each of the sample sizes at site 5, the decisions ranged between – 'don't spray', 'spray next week' and 'spray' (Table 6). The variation in the means reflects the uneven distribution of the thrips population at this low population density (see below for coefficient of variation values).

Table 6. Mean number of thrips per plant and spray decisions for each site at four different sample sizes (n= 50, 100, 150, 200) in November (16 Nov 99).

Sample size	Site 3		Site 4		Site 5	
	Mean	Decision	Mean	Decision	Mean	Decision
50 plants	0.04	Don't spray	0.44	Spray	0.04	Don't spray
100 plants	0.04	Don't spray	0.32	Spray	0.10	Spray
150 plants	0.06	Don't spray	0.17	Spray	0.11	Spray
200 plants	0.06	Don't spray	0.24	Spray	0.09	Spray next week

The December sample was also taken under relatively low thrips densities compared to the January sample, which showed much higher densities (still low in comparison to the 1998/99 season). On both of these sampling occasions there were no significant differences between sample sizes, and no differences in spray decisions at any of the sites (Tables 7, 8).

Table 7. Mean number of thrips per plant and spray decisions for each site at four different sample sizes (n= 50, 100, 150, 200) in December (21 Dec 99).

Sample size	Site 3		Site 4		Site 5	
	Mean	Decision	Mean	Decision	Mean	Decision
50 plants	0.08	Don't spray	1.20	Spray	0.00	Don't spray
100 plants	0.08	Don't spray	0.89	Spray	0.00	Don't spray
150 plants	0.03	Don't spray	0.72	Spray	0.05	Don't spray
200 plants	0.05	Don't spray	0.84	Spray	0.04	Don't spray

Table 8. Mean number of thrips per plant and spray decisions for each site at four different sample sizes (n= 50, 100, 150, 200) in January (19 Jan 00).

Sample size	Site 4		Site 5	
	Mean	Decision	Mean	Decision
50 plants	2.04	Spray	1.40	Spray
100 plants	1.64	Spray	1.63	Spray
150 plants	1.62	Spray	1.83	Spray
200 plants	1.73	Spray	1.73	Spray

The distribution patterns for all five Pukekohe sites are represented in Figure 2. All sites started the season with coefficient of variation (CoV) values above 1, which indicates a patchy or clumped distribution. The CoV values for Site 4 were generally lower than the other sites, which would be expected with a higher thrips population level. There was a general trend for the level of patchiness to reduce and tend towards a more random distribution later in the season as the thrips numbers increased (Figure 3). In addition lower CoV values were recorded for the 1998-1999 season when thrips pressure was considerably greater (see site descriptions below).

From these results it is obvious that thrips populations are very patchy in their distribution, particularly early in the season. However, considering there were no differences in the results for each of the sample sizes there is no need to increase the sample size. It is possible that at an even higher sample size (e.g. 500 plants) we may get a more accurate estimate of the thrips population, however, given the increased effort involved in taking a larger sample, it would be expensive to implement and may give little or no extra accuracy. As we demonstrate later in this season's monitoring results (Objective B), the current sampling system lead to very good control of thrips this season and this is another indication that a 50 plant sample is appropriate.

Figure 2. **Coefficient of Variation for onion thrips at all five Pukekohe sites for the 1999-2000 season**

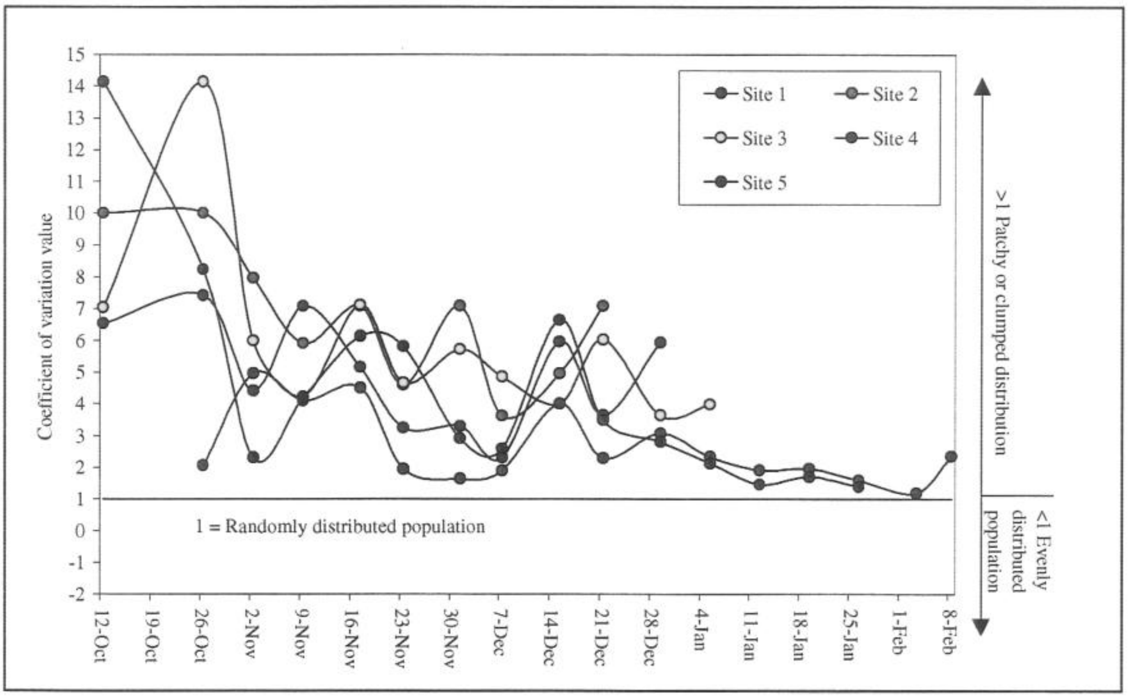
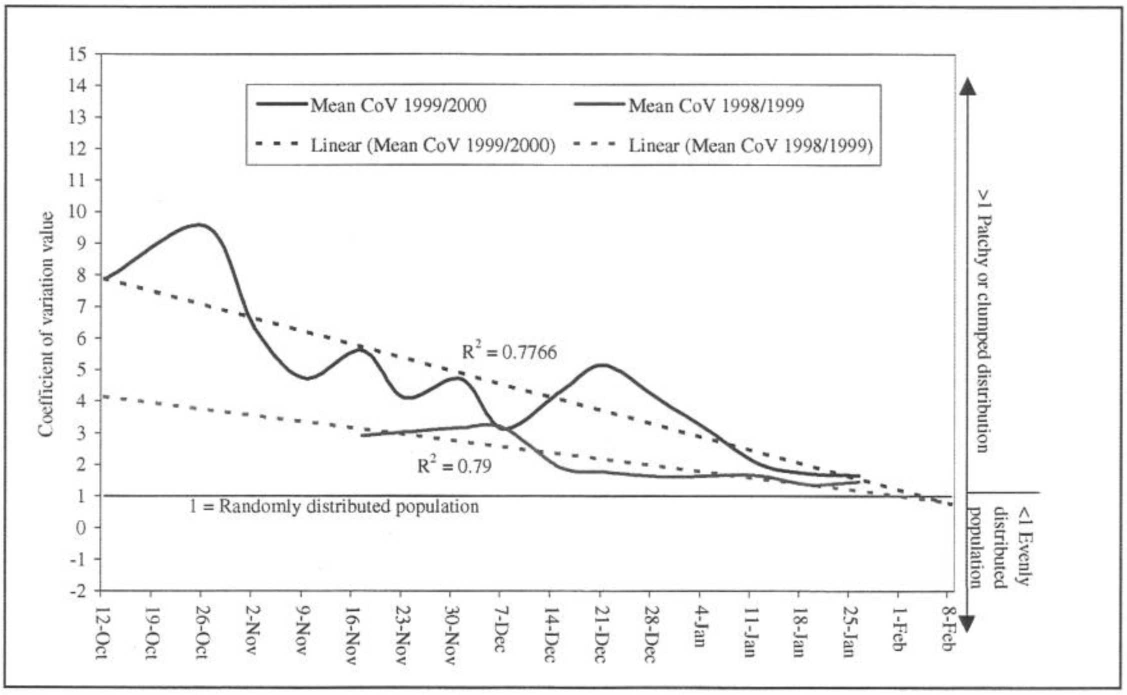


Figure 3. **Mean Coefficient of Variation values for onion thrips at the Pukekohe sites for the 1999-2000 and 1998-1999 seasons**



Objective B: Efficacy of the revised action threshold

The 1999-2000 season results for the revised action threshold of 5 thrips per 50 plants are described below for the individual sites. In general thrips population densities this season were much lower than those recorded in the Pukekohe region during the 1998-1999 season.

For consistency between sites all comparable graphs have the same y-axis values.

A full discussion for all sites follows individual site descriptions.

Site 1 (Figure 4)

On the initial sample date (12 Oct 99) this field recorded 4.5 thrips (all larvae) per 50 plants, which was the only occasion where the recommended action called for a further sample to be taken one week later (19 Oct 99), (sampling was at two weekly intervals in October). By the following week the thrips numbers had increased to 21.5 thrips (mostly larvae) per 50 plants, which is well in excess of the action threshold, and a recommendation to start a spray cluster was given.

The grower's response to the initial thrips monitoring result (4.5 thrips per 50 plants) was to apply a single spray OP (Lorsban) spray rather than waiting for a second sample to be taken. While this spray appears from the graph not to have reduced thrips numbers, 42 of the 43 thrips recorded the following week were larvae and may have been protected as eggs from the Lorsban spray. Thrips numbers had declined by the next sample date.

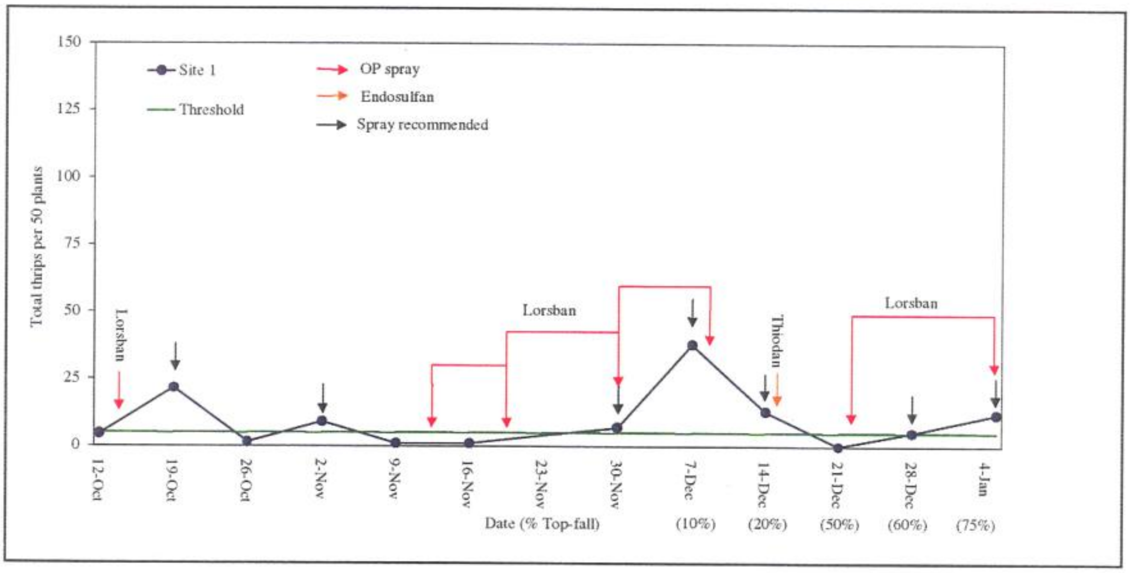
From the date of the first recommended spray (19 Oct 99) to the start of the first OP (Lorsban) cluster application (12 Nov 99) there was a period of 24 days, where the crop was unprotected. However, during this extended period thrips numbers showed considerable fluctuations and were low (below threshold) when the spray cluster began.

Good thrips control was achieved just before the majority of the crop started to fall (21 Dec 99) and only low numbers of thrips were recorded immediately prior to topping (4 Jan 00). The final OP (Lorsban) spray cluster, applied after 50% topfall, probably had little effect on final thrips levels at harvest due to poor coverage into the necks of the plants where the thrips population is concentrated.

This site showed excellent control of thrips numbers. While the threshold was exceeded seven times during the growing season, thrips numbers only reached relatively high levels above the threshold on two occasions (19 Oct 99 and 7 Dec 99).

Site 1 gives a good example of relatively few sprays being applied at the most appropriate timings to achieve season long thrips control.

Figure 4. Total onion thrips per 50 plants for Site 1 over the 1999-2000 growing season.



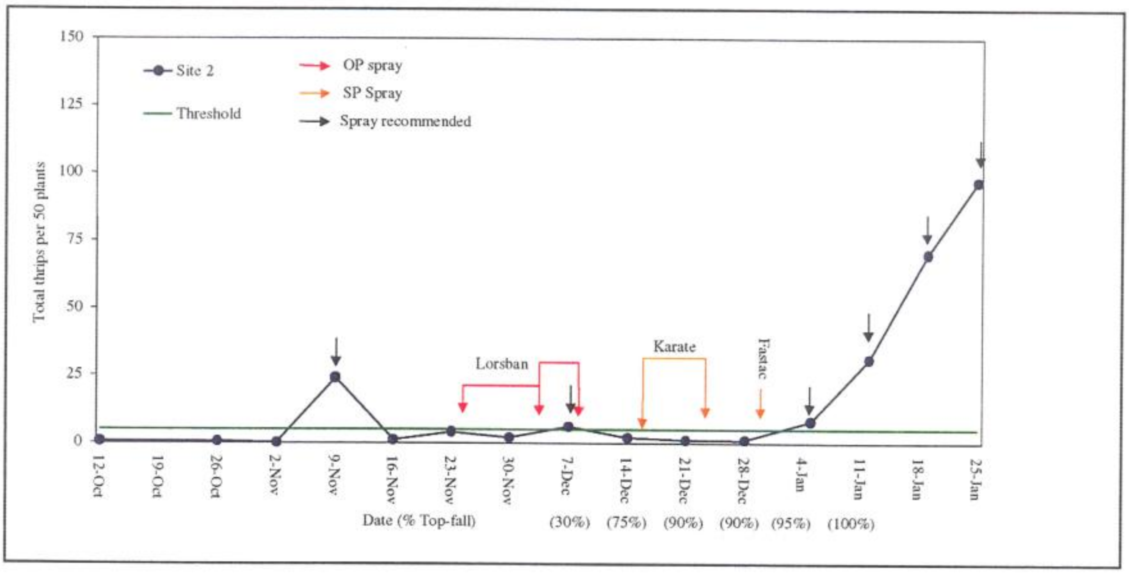
Site 2 (Figure 5)

Apart from an initial increase in thrips numbers on the 9 Nov 99 monitoring date (due largely to a high larval population on one plant (>20)) the population remained low until well after top-fall when most of the leaves had dried off (4 Jan 00). There was a considerable rise in the numbers of thrips per 50 bulbs after 4 Jan 00. However, only bulbs with green leaves remaining were sampled on these occasions, giving an artificially high record of thrips numbers. From field observations this season and last season, as the onions dry out after top-fall the majority of thrips in the fields either migrate out of the field or concentrate together on the few remaining green leafed plants.

A spray was not applied to the crop until 15 days after the initial recommendation to spray was given on 9 Nov 99. By this time two further samples had been taken and the thrips population appeared to have been reduced to below the threshold without chemical intervention as was also observed over this period at Site 1.

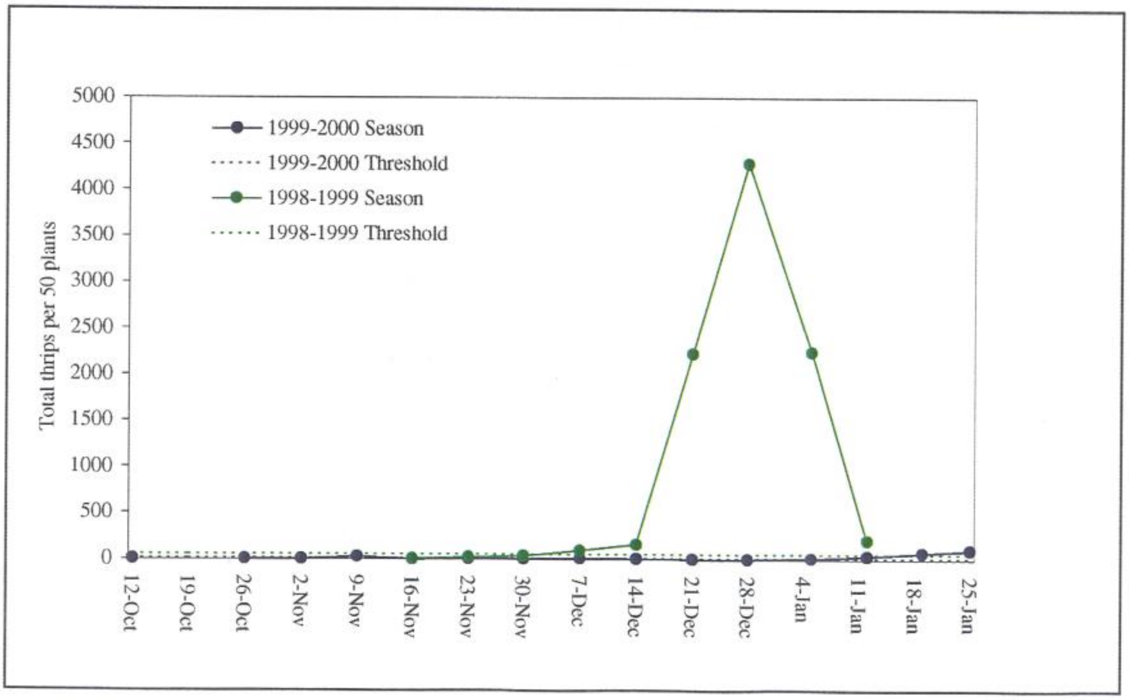
A cluster of 3 OP (Lorsban) sprays applied from 24 Nov to 8 Dec 99 appears to have suppressed the thrips population from increasing above the threshold. By the time the first SP (Karate) spray cluster was applied (16 Dec 99) coverage would have been limited as over 75% of the crop had fallen before the application. These SP spray applications were unlikely to have had much impact on the thrips populations within the necks of the plants.

Figure 5. Total onion thrips per 50 plants for Site 2 over the 1999-2000 growing season.



This site was also monitored last season and Figure 6 shows the differences in thrips populations between the two seasons. Peak numbers recorded this season were 44 times less than those recorded last season (97 and 4287 thrips per 50 plants, respectively). A direct comparison between the two seasons is difficult as the crops were grown under different environmental conditions and harvest was two weeks later this season. However, from the graph it is obvious that thrips control at this site was considerably better than last season.

Figure 6. Comparison of total onion thrips per 50 plants for Site 2 over the 1998-1999 and 1999-2000 growing seasons.

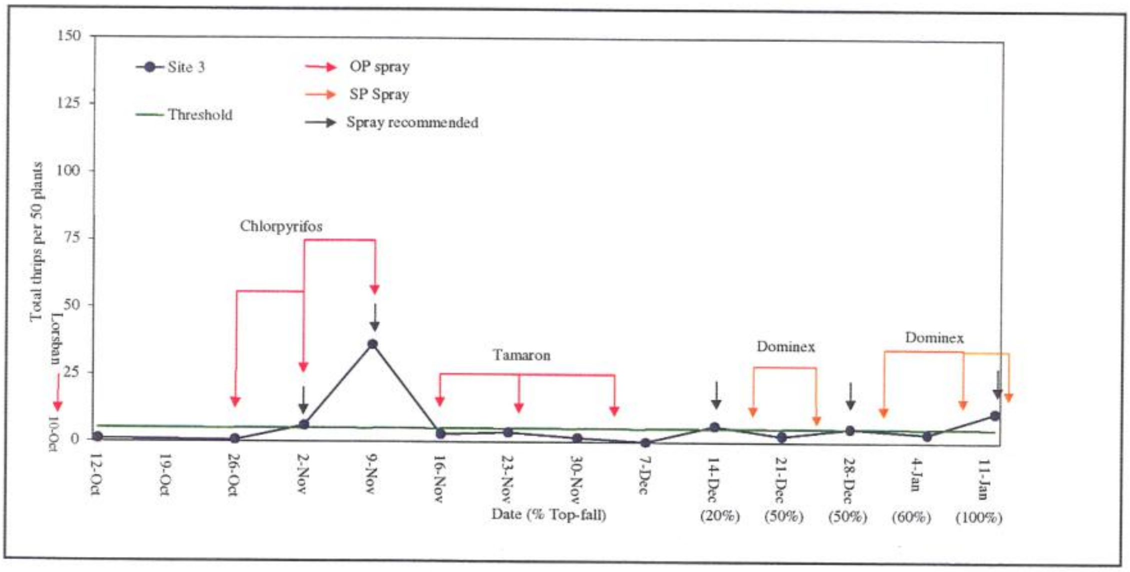


Site 3 (Figure 7)

Thrips numbers at this site were low at the commencement of monitoring. However, they did exceed the threshold on the 9 Nov 99 monitoring date. The majority of the 36 thrips found on this occasion were larvae on one plant (56%). The early thrips infestation appears to have been successfully controlled by insecticide application. The thrips population did not rise significantly above the threshold level for the remainder of the growing season.

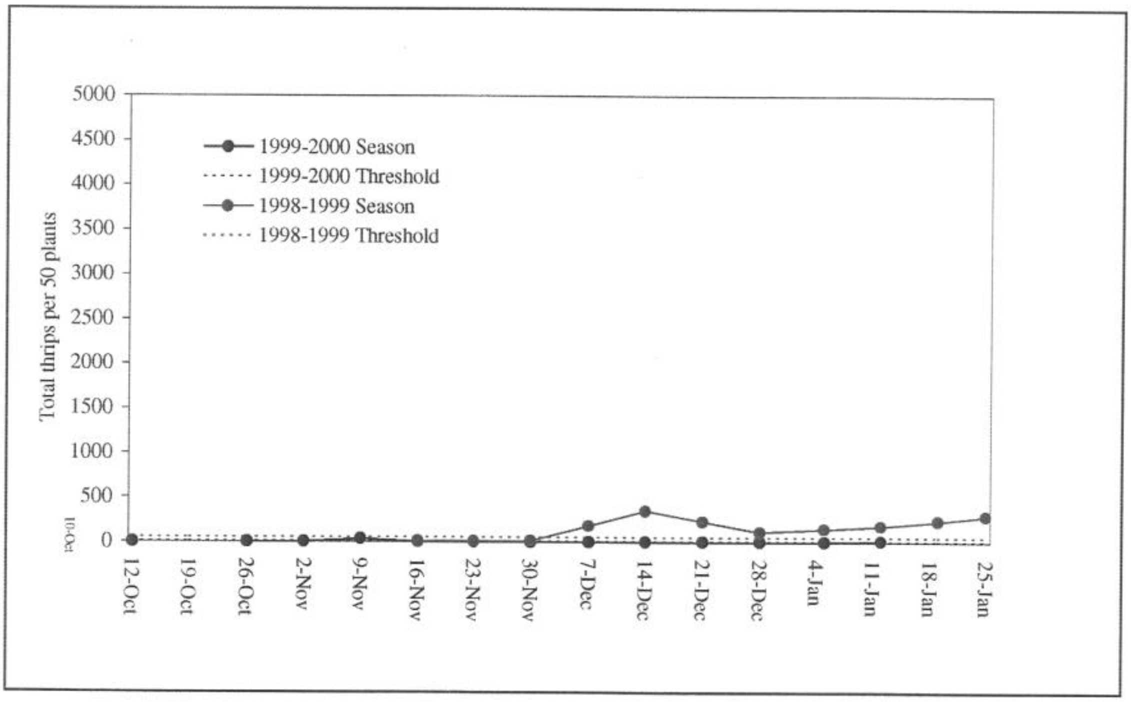
OP (Chlorpyrifos and Tamaron) spray clusters were used for the most susceptible stages of the growing season (before top-fall) and two SP (both Dominex) spray clusters were applied later in the season. Of the five SP sprays applied, four were applied after 50% top-fall and, as in Site 2, would not be expected to have achieved much control of the thrips population.

Figure 7. Total onion thrips per 50 plants for Site 3 over the 1999-2000 growing season.



The field directly adjacent to this field was monitored last season and Figure 8 shows the differences in thrips populations at this site between the two seasons. As at Site 2, thrips control this season was considerably better than last season even considering that this site showed the best control record for last season. Peak numbers recorded this season were 10 times less than those recorded last season (36 and 351.5 thrips per 50 plants, respectively).

Figure 8. Comparison of total onion thrips per 50 plants for Site 3 over the 1998-1999 and 1999-2000 growing seasons.



Site 4 (Figure 9)

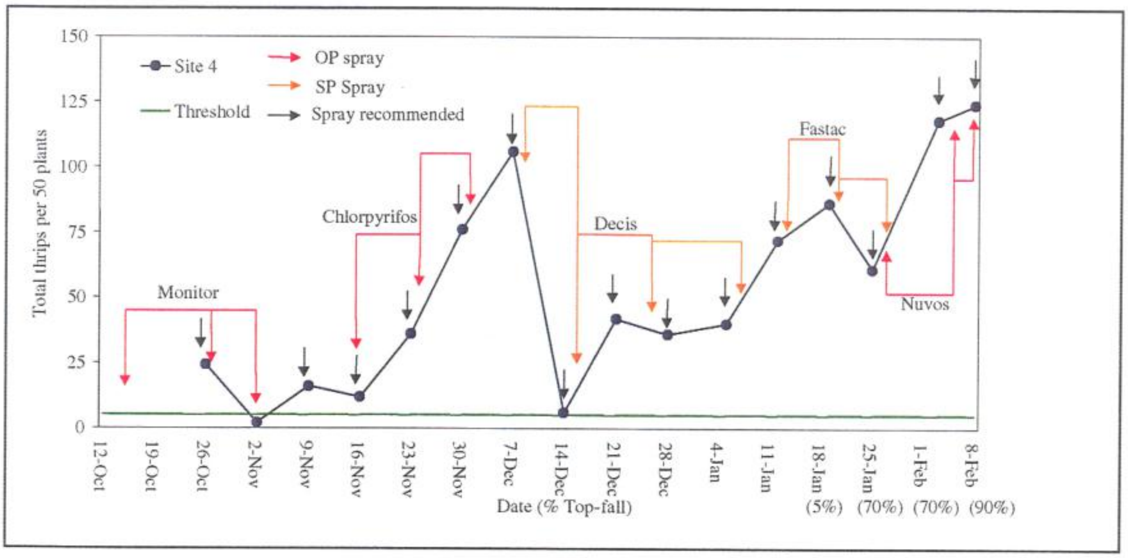
Monitoring commenced at this site on 26 Oct 99 and the field was already well in excess of the threshold (24.25 thrips per 50 bulbs). An OP (Monitor) spray cluster had already commenced on this field (first spray on 14 Oct 99) after the threshold had been exceeded on an adjacent field on 12 Oct 99. This spray cluster did reduce the thrips numbers to below the threshold by the final spray. This was the only occasion during the season that the thrips population at this field remained below the threshold.

The thrips population appeared to be increasing rapidly in late November / early December (up to 106 thrips per 50 plants) despite the application of another OP (Chlorpyrifos) spray cluster.

Thrips numbers were significantly reduced by 14 Dec 99 following the application of the first SP (Decis) spray at the site. This effect was short-lived and by the completion of the 4-spray SP (Decis) cluster, thrips numbers had increased to 72 thrips per 50 plants.

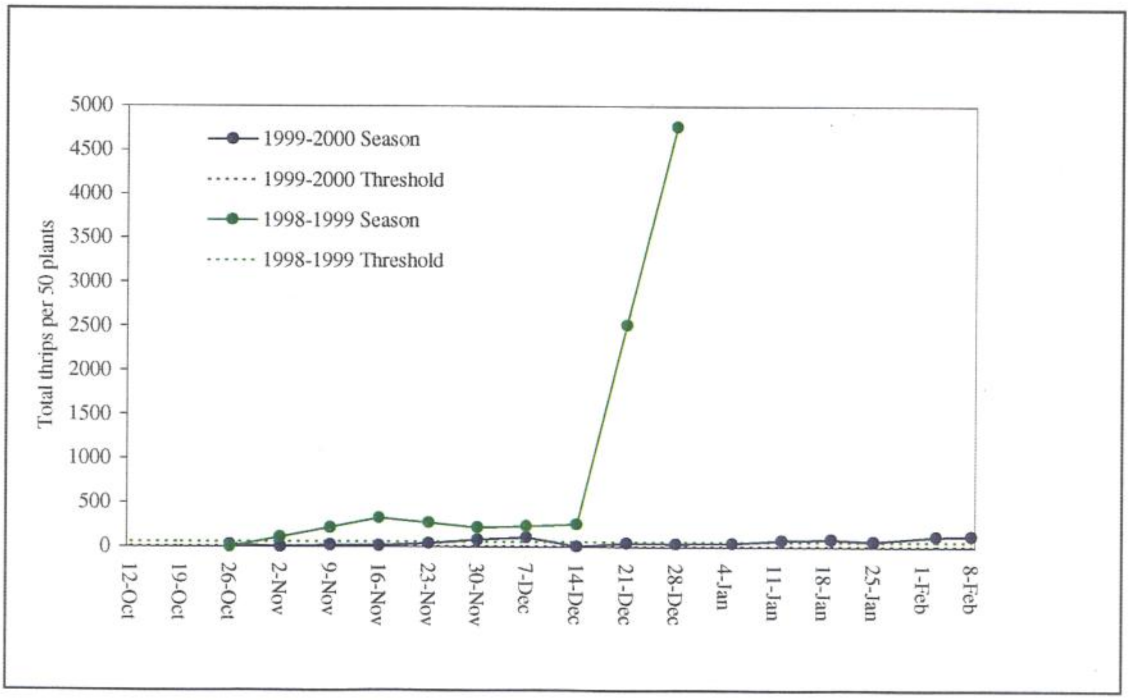
By the end of the season it was evident at this site that both OP and SP sprays and sprays applied after top-fall were inadequate to control thrips numbers. Martin *et al.* will discuss the failure of the sprays at this site.

Figure 9. Total onion thrips per 50 plants for Site 4 over the 1999-2000 growing season.



While this site showed the highest thrips populations of the five sites monitored this season, when this site is compared with the levels of thrips recorded at a nearby field last season, it shows favourable levels of control (Figure 10). Peak numbers recorded this season were 38 times less than those recorded last season (124 and 4767 thrips per 50 plants, respectively).

Figure 10. Comparison of total onion thrips per 50 plants for Site 4 over the 1998-1999 and 1999-2000 growing seasons.



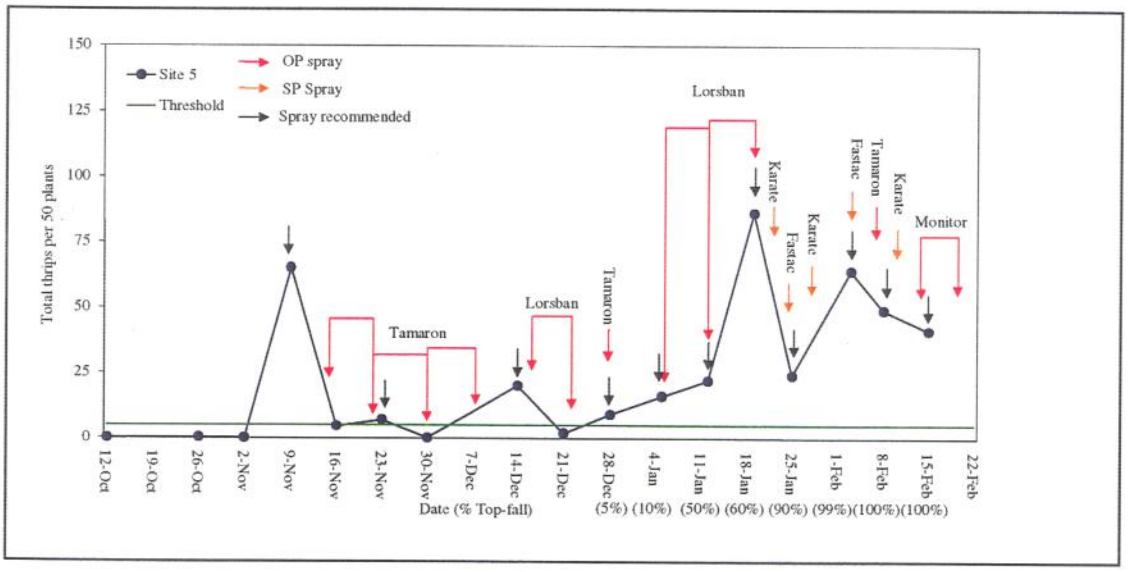
Site 5 (Figure 11)

Site 5 also showed a sudden increase in thrips numbers on 9 Nov 99, but had reduced again by the following sampling. This reduction could be attributed to either the first spray of an OP (Tamaron) spray cluster or could possibly have just naturally reduced as it did at the other sites that remained unsprayed.

Thrips numbers rose again on 14 Dec 99 and were again suppressed by the following sampling date after the application of the first spray of the next OP (Lorsban) spray cluster.

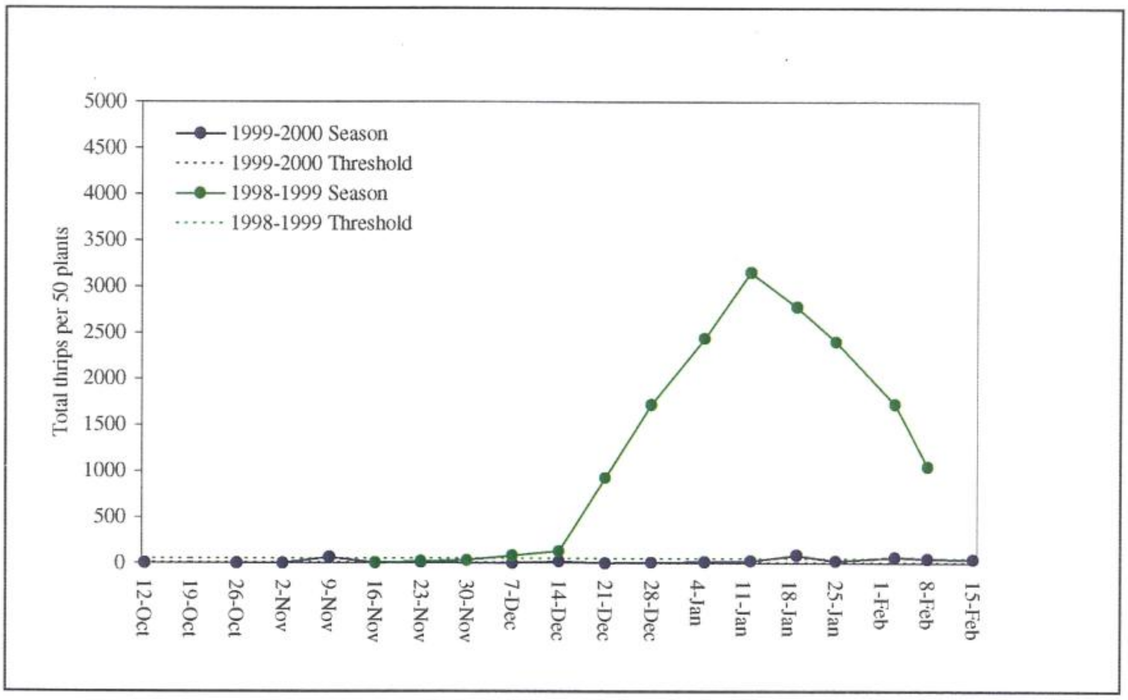
Following this reduction, thrips numbers again rose steadily to peak at 86 thrips per 50 plants on 18 Jan 00. The first of the SP sprays was applied two days later and while the SP sprays appear to have had some impact on thrips populations it is likely that success was limited by top-fall in the crop (90% of plants had fallen by 25 Jan 00).

Figure 11. Total onion thrips per 50 plants for Site 5 over the 1999-2000 growing season.



While this site did not achieve a high level of control by maintaining thrips levels around the threshold, there was a significant improvement on last season's results (Figure 12). Peak numbers recorded this season were 36 times less than those recorded last season (86.25 and 3157 thrips per 50 plants, respectively).

Figure 12. Comparison of total onion thrips per 50 plants for Site 5 over the 1998-1999 and 1999-2000 growing seasons.



All Pukekohe sites

The large increase in thrips numbers experienced at Sites 1 and 4 in mid-October was unexpected for this time of year when populations should be reproducing at a much slower rate. Due to these early population increases we believe it would be advisable to begin sampling 1-2 weeks earlier (at the beginning of October) and that weekly sampling of 50 plants be implemented rather than two-weekly samples of 100 plants.

The increase in thrips populations at Sites 2, 3 and 5 on 9 Nov 99 and subsequent decrease by the 16 Nov 99 sample date correlates to an increase in the minimum temperature records (approximately 4-6°C higher) for the region from 2 Nov 99. By 14 Nov 99 minimum temperatures had reduced again to levels similar to those observed before this period (pers. comm. Richard Wood).

Excellent control of thrips populations was observed at Sites 1, 2 and 3 this season with thrips numbers being contained at or around the action threshold level. Sites 4 and 5 (both late sites) showed much less control success than the earlier sites despite greater insecticide use. However, all sites this season were able to achieve considerably better thrips control than the previous season. A large proportion of this success was attributable to the combination of the lower action threshold and earlier insecticide intervention.

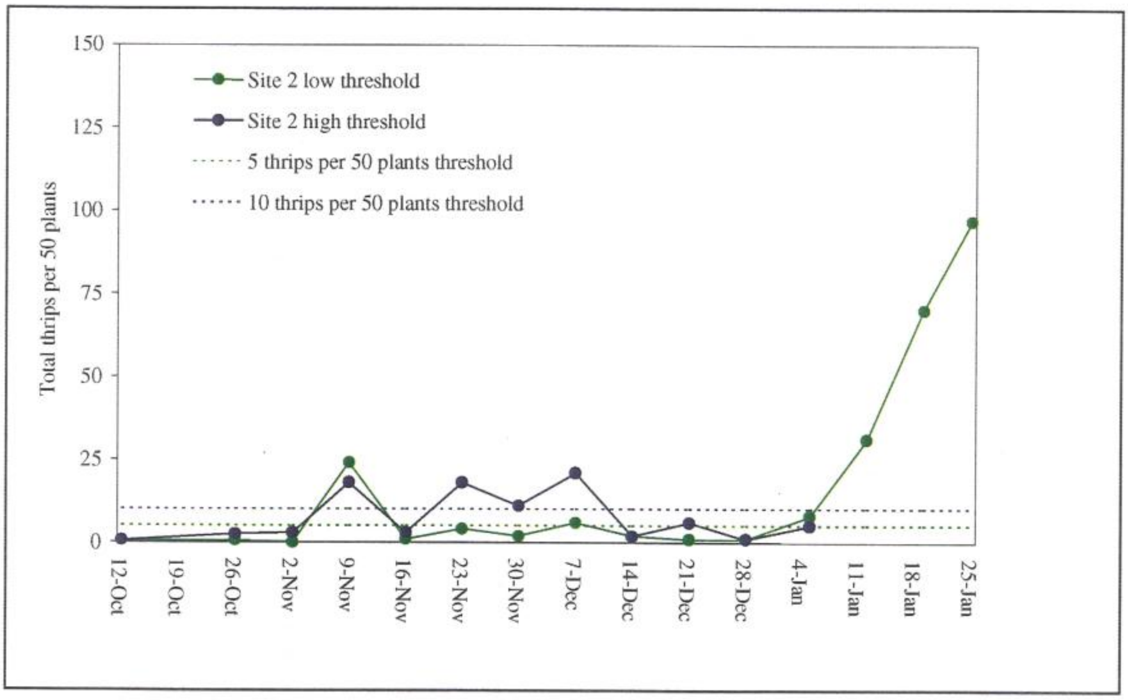
Good early season control, as was demonstrated on sites 1,2 and 3, is probably the most important factor for reducing thrips numbers at harvest. Potentially only one or two spray clusters are necessary over the early season period just prior to top-fall.

It appears that early and mid-season harvested onions have lower thrips populations present at topping and require less insecticide intervention over the season than later crops. It may be that the level of insecticide application needed to protect a late crop is not sustainable.

High versus Low spray threshold

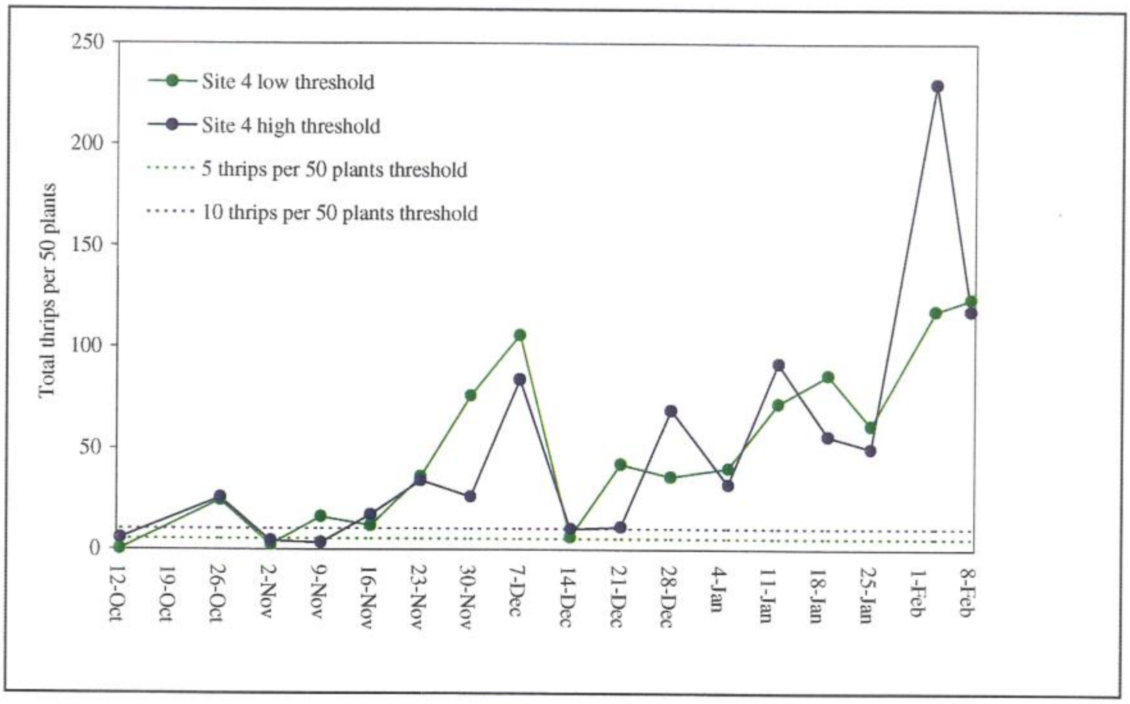
The two sites that were made available to have fields at different threshold levels were Sites 2 and 4. At Site 2 thrips numbers were similar in both fields until 23 Nov 99 when thrips numbers in the high threshold field (10 thrips per 50 plants) rose above those in the low threshold field (5 thrips per 50 plants) (Figure 13). The differences in thrips numbers between these two fields however, cannot be attributed to spray action, as the first application was not made until 24 Nov 99. By the completion of the first spray cluster thrips numbers had reduced to low levels at both fields. Sprays were applied to both fields on the same dates, therefore, any differences between fields were most likely due to biotic factors and not threshold levels.

Figure 13. Total onion thrips per 50 plants for Site 2 over the 1999-2000 growing season at two threshold levels (5 or 10 thrips per 50 plants).



At Site 4 thrips numbers were very similar in both threshold fields throughout the entire monitoring period (Figure 14). There was only one occasion when a spray recommendation was made for the low field only (9 Nov 99) and as this spray was not applied until after the 16 Nov sample date when both fields exceeded threshold, there was no difference in spray applications between fields.

Figure 14. Total onion thrips per 50 plants for Site 4 over the 1999-2000 growing season at two threshold levels (5 or 10 thrips per 50 plants).



Canterbury and Manawatu results

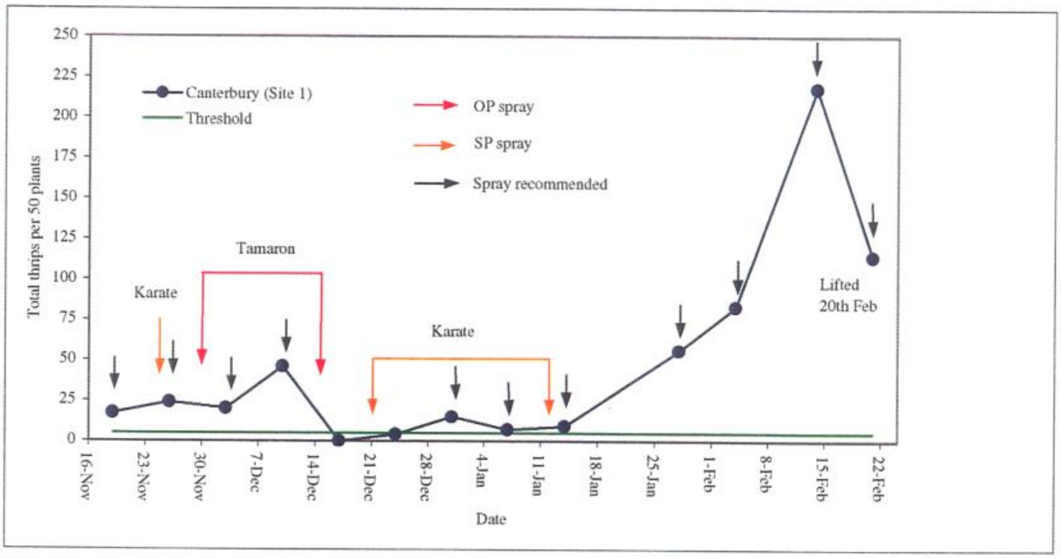
Canterbury

Due to higher thrips infestation levels at Sites 1 and 2 in Canterbury, Figures 15 and 16 have greater y-axis values (up to 250 and 1200 thrips/50 plants respectively) than all other sites (up to 150 thrips per 50 plants).

Site 1 (Figure 15)

The initial thrips population was recorded as 17 thrips per 50 plants on 19 Nov 99 (Figure 15). An SP spray (Karate) followed by an OP spray (Tamaron) corresponded with a decrease in thrips population below the threshold (0 thrips/50 plants , 17 Dec 99). Two SP sprays (Karate) on 21 Dec and 12 Jan appear to have maintained the thrips levels around the threshold up until 14 Jan 00. No further sprays were applied. Thrips numbers had increased to a maximum of 218 thrips per 50 plants by 14 Feb 00. The plot was lifted on 20 Feb 00. A post-lift assessment on 21 Feb 00 on thick-necked onions yielded a total of 114 thrips per 50 plants.

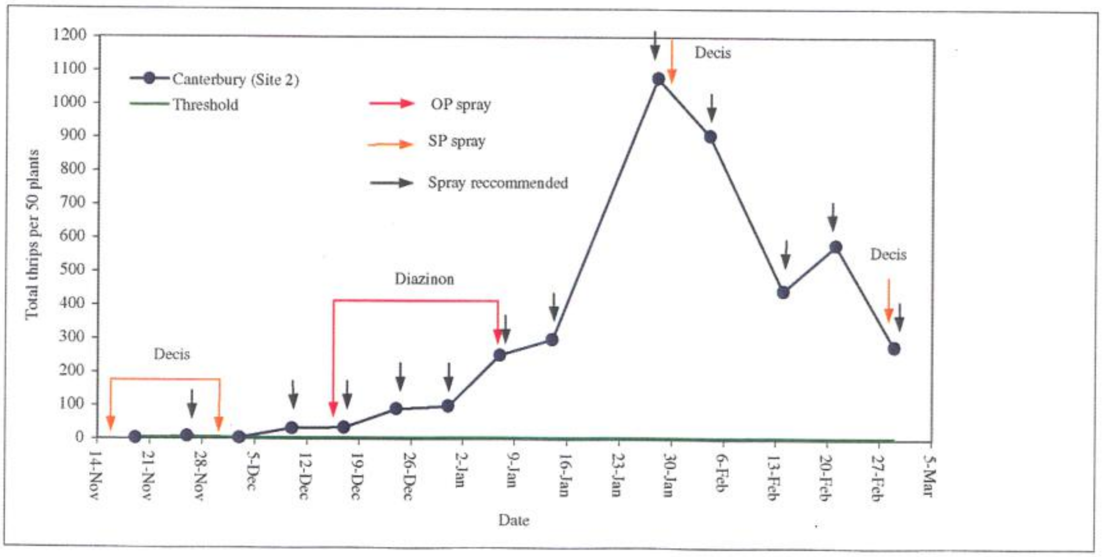
Figure 15. Total onion thrips per 50 plants for Canterbury (Site 1) over the 1999-2000 growing season.



Site 2 (Figure 16)

Thrips numbers were below the threshold when sampling commenced on 19 Nov 1999. Two SP sprays were applied on 15 and 30 Nov 99 (Figure 16). Thrips numbers began to increase markedly above the threshold from 10 Dec 99. Two OP sprays (Diazinon) were applied on 16 Dec 99 and 7 Jan 00, but thrips numbers increased to 1078 thrips per 50 plants on 28 Jan 00. An SP spray was applied on 29 Jan 00, after which the numbers decreased to 444 thrips per 50 plants (14 Feb 00).

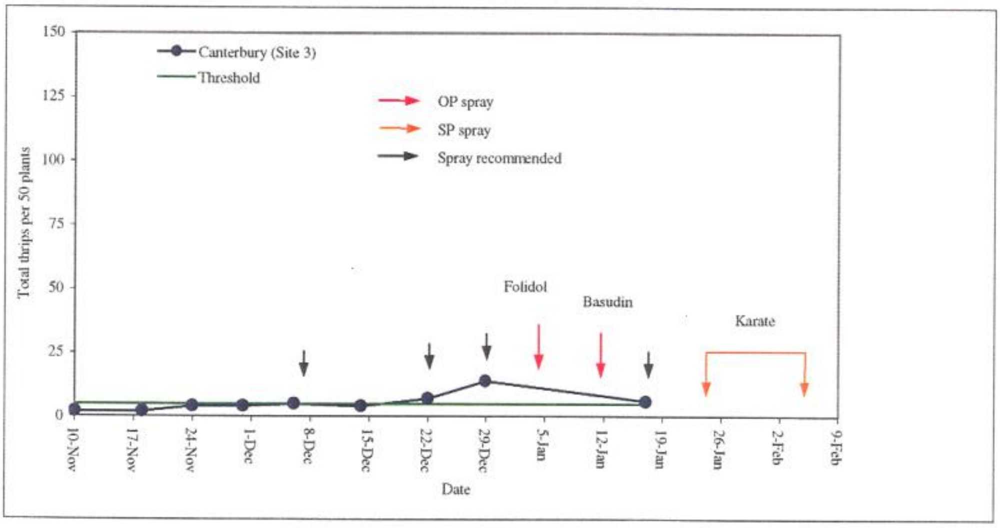
Figure 16. Total onion thrips per 50 plants for Canterbury (Site 2) over the 1999-2000 growing season.



Site 3 (Figure 17)

The thrips population remained at or below the threshold from 10 Nov 99 to 14 Dec 99, after which levels increased to a maximum of 14 thrips per 50 plants (29 Dec 99) (Figure 17). No sprays were applied during this time period. Subsequent application of two OP sprays (Folidol and Basudin, 4 and 11 Jan 00 respectively) appeared to reduce the population towards the threshold. Two SP sprays (Karate) were applied on 24 Jan and 3 Feb 00. However no thrips data were available for this period, hence the effect of this SP application on thrips levels is not known.

Figure 17. Total onion thrips per 50 plants for Canterbury (Site 3) over the 1999-2000 growing season.

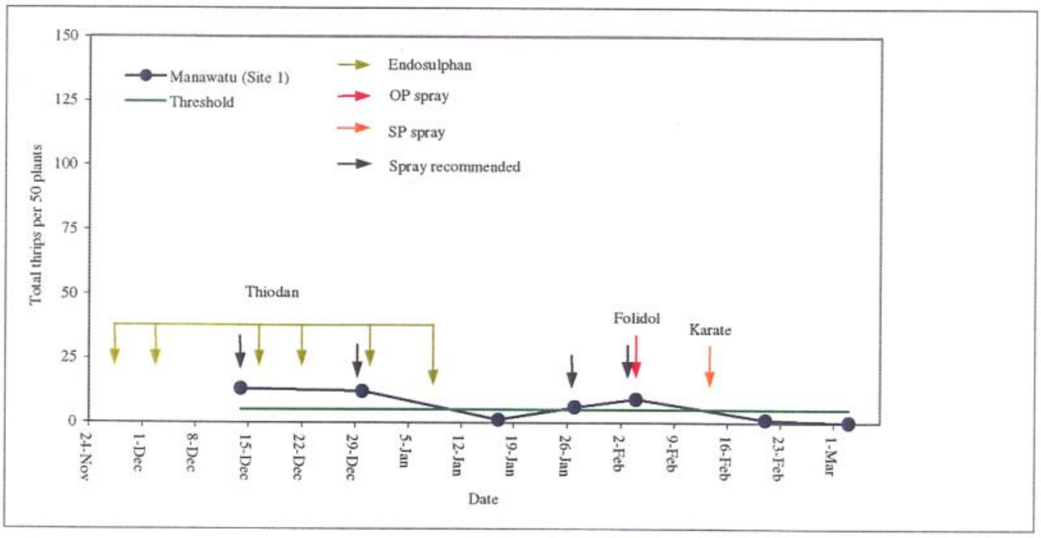


Manawatu

Site 1 (Figure 18)

A heavy cluster (6 consecutive sprays) of Endosulphan (Thiodan) was applied at the start of the growing period when thrips numbers were above the threshold (Figure 18). This appeared to reduce thrips numbers from 13 thrips per 50 plants (10 Dec 99) to just one thrips per 50 plants (17 Jan 00). A slight increase in thrips numbers (up to 9 per 50 plants, 4 Feb 00) appeared to be arrested by a single OP spray (Folidol, 4 Feb 00) followed by a single SP spray (Karate, 15 Feb 00). Thrips numbers then remained below the threshold until the end of sampling (3 Mar 00).

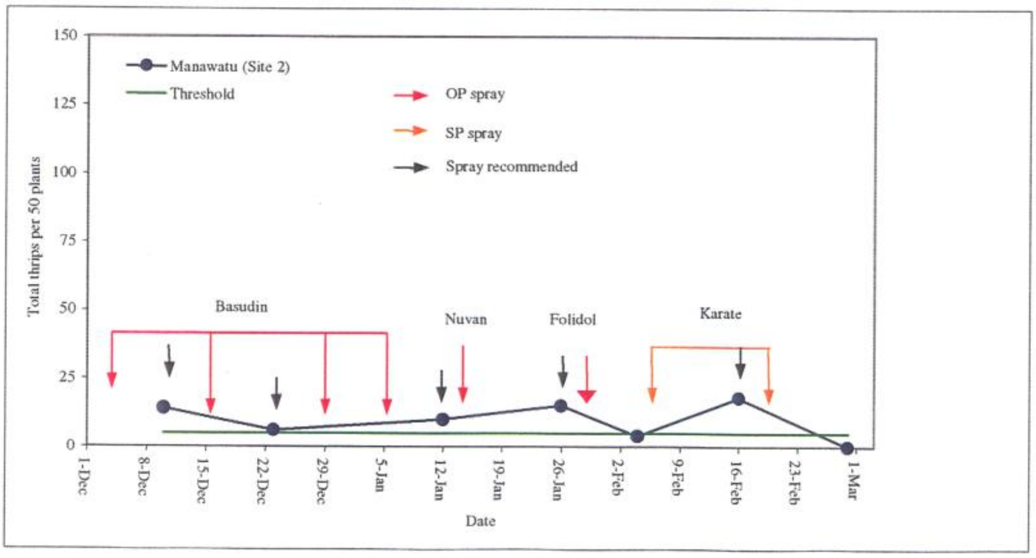
Figure 18. Total onion thrips per 50 plants for Manawatu (Site 1) over the 1999-2000 growing season.



Site 2 (Figure 19)

The initial thrips population was 14 thrips per 50 plants (10 Dec 99) (Figure 19). A cluster of OP sprays (Basudin) applied at the start of the growing period followed by two single OP applications (Nuvan and Folidol) appeared to suppress the thrips population in the period 10 Dec 99 to 26 Jan with thrips numbers above the threshold, but below 20 thrips per 50 plants. An SP cluster (Karate) applied towards the end of the growing period (5 and 18 Feb 00) appeared to maintain this degree of control with thrips numbers eventually falling below the threshold by the final sampling date (29 Feb 00).

Figure 19. Total onion thrips per 50 plants for Manawatu (Site 2) over the 1999-2000 growing season.



Canterbury and Manawatu summary

Good levels of thrips control were observed for both Manawatu sites and Site 3 from Canterbury. At Site 1 in Canterbury it is obvious that sampling commenced too late to pick up early infestations of thrips. Despite this, sprays applied prior to mid Jan were effective in controlling the population. Both the lack of sprays after mid Jan and the extended intervals between sprays prior to this could have contributed to the high levels of thrips by the end of sampling. Site 2 in Canterbury suffered from high thrips populations starting from mid Dec. It is likely that the rapid increase in thrips numbers was also due to too few sprays and the long intervals between spray applications.

CONCLUSIONS AND RECOMMENDATIONS

Objective A: Sampling accuracy of the revised monitoring system

Considering the very conservative action threshold that was set for this season and the relatively good control of thrips in fields under this threshold, increasing the sample size from 50 plants per field would be of limited value. The low action threshold value was arrived at with the consideration of several 'safety' factors to account for uneven population distributions and a small sampling unit. We recommend retaining the 50 plants sampling unit next season.

Following a rapid increase in thrips numbers over a one week period in mid-October at two sites we recommend commencing sampling at the beginning of October, and increasing sampling times to weekly counts of 50 plants in October (current recommendation is for two-weekly counts of 100 plants).

Objective B: Efficacy of the revised action threshold

It is probable that good early season control, as was demonstrated on Sites (Pukekohe) 1, 2 and 3, is the most important factor for reducing thrips numbers at harvest. Potentially, only one or two spray clusters are necessary over the early season period just prior to top-fall (possibly one OP cluster followed by either another OP, Endosulfan or SP cluster at five day intervals). To get the maximum benefit from SP sprays (where they remain effective) the recommended start date may have to be brought forward to mid-late November for early crops and early-mid December for later crops to enable a full cluster to be applied before topfall. Sprays will have reduced effectiveness following topfall, therefore harvest techniques may have far greater impact on the number of thrips in the crop than late season sprays, this will be discussed by Tomkins *et al.*

Earlier crops showed lower thrips populations and required lower insecticide use than the two later crops and may be more environmentally and economically sustainable to grow in the future.

It was intended that a post-harvest bulb assessment be carried out on onions from each site to ascertain the efficacy of the revised action threshold. However due to funding restrictions this was not approved. However, it is hoped that information gathered by Tomkins *et al.* will provide an indication of any post-topping increases in thrips numbers. This research will be important in showing where during the growth, harvest or shipping chain, the thrips numbers are increasing. Following a very good growing season with relatively low thrips infestation in the field, if thrips numbers are still high at market destinations our whole approach to control may have to change from pre-harvest control measures to harvest and post-harvest measures.

From this season's results over the five sites in the Pukekohe region, excellent control of onion thrips was achieved in the three early to mid season sites, and reasonable control in comparison to last season was achieved in the two late season sites. Good levels of thrips control were observed for both Manawatu sites and Site 3 from Canterbury and this level of control corresponded with appropriate spray applications. Sites 1 and 2 of Canterbury had good control at the start of their respective growing periods, but thrips numbers greatly exceeded the threshold towards the end and middle of their respective growing periods. This was most likely due to lack of spray applications at the time thrips numbers began to increase and too long an interval between spray applications.

Due to these results we recommend retaining the current action threshold of 5 thrips per 50 plants.

ACKNOWLEDGEMENTS

We would like to thank the members of the Onion Exporters Association, in particular those whose properties were used for these trials. Thank you also to Richard Wood for organising monitoring sites and for collecting spray dairies and Xenia Meier for excellent technical assistance.

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